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(71) Applicant: HERCULES INCORPORATED [US/US];  
Hercules Plaza, 1313 North Market Street, Wilmington, DE  
19894-0001 (US).

(72) Inventors: HASSLER, Thord; 314 Norwich Lane, Lan-  
denburg, PA 19305 (US). ECHT, Elliott; 2526 Berwyn  
Road, Wilmington, DE 19810 (US). GAST, John; 10  
King's Grant Road, Hockessin, DE 19707 (US).

(74) Agent: RAMSTAD, Polfy, E.; Hercules Incorporated,  
1313 North Market Street, Wilmington, DE 19894-0001  
(US).

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(54) Title: PROCESS COMBINING FUNCTIONAL ADDITIVES AND DRYER SECTION PASSIVATION

(57) Abstract: Methods for considering system-wide operation parameters in a paper machine for regulation of efficiency of func-  
tional additives, e.g., strength agent and/or sizing agent, and of operations of a paper machine manufacturing cellulosic sheet com-  
prising a functional additive are disclosed. Methods include combinations of functional additive in the wet end of a paper machine  
and dryer passivation in the dryer section of a paper machine. Also disclosed are methods for controlling operation parameters in  
disparate segments of a paper machine; methods for measuring variables and adjusting parameters which couple operations in dis-  
parate segments of a paper machine.

## PROCESS COMBINING FUNCTIONAL ADDITIVES AND DRYER SECTION PASSIVATION

### Field of the Invention

5           This invention relates to methods of manufacturing cellulosic products such as paper and paperboard. More specifically, the invention relates to a process for preparing paper comprising a strength and/or sizing agent, and to methods of dryer passivation.

### Background

10           Linting in cellulosic products, e.g., paper and paperboard, is a problem that can arise when fibers and fiber fragments are poorly bonded in the sheet. These fiber fragments become dislodged from the paper and contaminate surfaces in contact with the paper. Linting can occur during manufacture or during use of the product. One cause of linting is sticking of the surface of the paper to the dryers. Linting results in deposits of fibers and fiber fragments in the dryer section, on the sheet, and in the paper processing  
15           equipment such as paper coating and printing machines.

          Another limitation to paper quality is poor smoothness. Paper smoothness is important for, e.g., paper printing. One factor limiting paper smoothness is the protrusion of fibers and fiber fragments above the surface of the sheet. This is sometimes called fiber rising.

20           Linting, fiber rising and paper smoothness are interrelated properties of the paper. Reduction in linting, reduced fiber rising and improved smoothness can be accomplished by increasing the surface strength of a cellulosic sheet, e.g., paper or paperboard.

          There are many methods used in the industry to determine strength of cellulosic  
25           sheets, e.g., paper sheets. All the methods in some way attempt to simulate the use of the paper product and how this eventually might be ruptured. By way of example tensile strength, tear strength, surface strength and wet strength are all different strength properties of paper and paperboard determined by different methods. For surface strength a common method is Scott Bond. This is described in TAPPI standard test  
30           method, which is available and known to those of ordinary skill in the art.

A number of different methods are used to improve the strength properties of paper. Beating will increase the strength, but beating requires considerable energy input, and it is often combined with a chemical additive to increase the bonding of fibers. Additives that increase the bonding of the fibers also increase various strength measures of the paper (with the exception of tear strength that is not affected by the addition of strength additives). In order to obtain a paper product with the desired strength characteristics, therefore, many different additives are available for increasing the surface strength of paper.

It is well known that natural and derivatized starches and gums, as well as synthetic polymers, e.g., synthetic hydrophilic polymers, can be effective in improving the strength of paper and paperboard. These materials act primarily by increasing the strength and number of bonds between fibers.

The usefulness of strength agents to actually increase strength is limited by a number of factors. Increase in fiber to fiber strength is related to inherent adhesive properties of all strength additives. Not only do they increase the adhesion between fibers, but they also increase the adhesiveness of the sheet to machine components. One area of particular concern is strength agents' tendency to increase sheet adhesion in the dryer section, e.g., to dryer drums and/or fabrics. Adhesion in the dryer section can be notable on the dryer drums, and is dependent on the relationship between temperature, moisture, and the thermal properties of the adhesive substance. The increased adhesion can result in increased fiber rising and linting thus reducing the positive effect the strength additive will have on fiber rising, linting and surface smoothness. Increased adhesion of the sheet to a dryer drum also means that greater force is required to "peel" the sheet off of the drum. Because the greater applied force increases the risk of paper breaks, this can limit machine speed, hence productivity. Thus, addition rate of strength agent is often limited by the agents' unwanted effect of increased adhesion to dryer section components. Generally the tendency to adhesion and deposition increases at increased addition of the strength agent.

Adhesion is an especially important problem for latex. Latices, i.e., latex, its derivatives, and related substances, are strength agents that inherently tend to be more adhesive than most other strength agents. In order to reduce runnability problems when using a strength agent comprising a latex, e.g., deposition and/or paper breaks in the dryer section, it is necessary to slow down machine speed and/or dry the cellulosic sheet less aggressively, e.g., at lower temperatures. Use of either or both of these solutions to compensate for latex adhesion reduces productivity, hence increases production costs. Despite the excellent strength imparting properties of latices, their adhesive properties limit the amount of latex that can be added, and increase the cost of producing latex-strengthened cellulosic products.

One effect of increased drying rate is reduction in rate of hydrolysis. The rate of hydrolysis increases exponentially with temperature for cellulose reactive functional additives such as sizing agents and strength additives. Minimizing the time the additive is kept at high temperature in the presence of water, therefore, can significantly reduce the hydrolysis side reaction, thereby decreasing the loss of functional additive. This reduction in loss of functional additive, i.e., increase in yield of functional additive, can be taken advantage of by reducing the addition rate of the functional additive.

Paper makers strive to produce paper with high uniformity. Uniformity results in several advantages, including cost minimization and/or improving conversion of the paper product to the final product, e.g., printing of newsprint to become a newspaper. One disadvantage of cross machine nonuniformity is that addition rate of functional additives must be set to meet the specification across the whole width of the paper. If the moisture profile is nonuniform there will be a higher loss of functional additives at these points with higher moisture. The consequence of this is excessive use of functional additives at other points where the moisture is lower. Addition rate can be minimized if paper is more uniform particularly with regard to moisture profile.

There is a need in the industry for methods to improve the quality of paper and paper board by reducing linting and fiber rising and improving smoothness. There is also a need for a method to adjust the use of two methods (strength additives added before

sheet formation and dryer section passivation) that individually can be used to reduce fiber rising of paper and paperboard.

There is a need in the industry for methods to improve the functionality of chemical surface strength additives added before formation of the sheet by the reduction of the increase in adhesion of the sheet to surfaces in the drying section caused by these additives.

There is also a need in the industry to provide a method for more rapid reaction of cellulose reactive additives by improving heat transfer. Such cellulose reactive additives include sizing agents, wet strength agents and dry strength agents.

There is also a need in the industry to improve the usefulness of functional paper additives by reducing their tendency to form deposits or increase sticking of the paper in the dryer section.

There is also a need in the industry for improved methods for the use of latices as strength agents for cellulosic products, such as paper and paperboard.

#### Disclosure of the Invention

In one aspect, the present invention provides a method for reducing the level of functional additive needed to obtain a desired level of a property, e.g., strength or sizing.

In another aspect, the present invention provides a method for increasing the yield obtained by a given rate of addition of a functional additive. In yet another aspect, the present invention provides a method for employing higher addition rates of functional additive than were previously feasible.

Thus, the present invention provides a method for reducing the addition rate of functional additive, e.g., strength and/or additive, by increasing machine speed and/or ease of release of cellulosic sheet from a dryer drum and/or dryer fabric. In the case of functional additives subject to hydrolysis, the rate of addition is also reduced by the decreased opportunity for hydrolysis and/or increased opportunity for cellulose reaction that results from faster drying. In the case that functional additive is used, exclusively or partially, for increased smoothness, reduced fiber rising, and/or reduced linting, less

functional additive needs to be added as adhesion to a dryer surface becomes less of a problem.

5 The present invention also provides methods obtaining increased yield from functional additives that are added to a fiber furnish at a given rate. By providing for more easy and rapid release from dryer surfaces, and by providing less opportunity for hydrolysis, a given amount of functional additive, e.g., strength and/or sizing agent, can impart a greater degree of the intended property, e.g., strength and/or sizing, than could previously be obtained.

10 The present invention also provides methods for increasing the level of functional additive, e.g., strength and/or sizing additive, including additives subject to hydrolysis, while reducing adhesion and deposit formation in the drying section. This enables the paper manufacturer to use a combination of weaker fibers, more fillers and less refining for adjusting of paper properties and cost, or to enhance properties, e.g., strength and/or sizing, of paper being produced.

15 The present invention provides a method for adjusting parameters in a paper machine comprising a dryer section and producing a cellulosic product from a fiber furnish comprising a functional additive, the method comprising: a) deciding whether to implement a dryer section treatment program; b) if yes, then determining what dryer section treatment program to use; c) implementing a dryer section treatment program; 20 and d) adjusting at least one paper machine parameter based on the dryer section treatment program.

The deciding is preferably based on at least one of: a1) deciding to improve paper uniformity; a2) deciding to improve at least one of fiber rising, linting, and smoothness; and a3) deciding to increase dryer section temperature. Preferably, a treatment agent is 25 selected, and the determining is based on at least one of: b1) how well the treatment agent prevents deposition on the dryer surface; b2) how well the treatment agent maintains as a film under dryer conditions; b3) how chemically stable the treatment agent is; b4) how stable the treatment agent is with regard to at least one of pitch and stickies; b5) non-adhesiveness of the treatment agent; b6) how well the treatment agent avoids

adverse effect on sheet properties. Preferably, the dryer section comprises at least one of a dryer drum and a drying fabric, and the implementing preferably comprises application of a treatment agent to at least one of the dryer drum and the dryer fabric. The adjusting preferably comprises at least one of: d1) adjusting the amount of functional additive; and  
5 d2) adjusting dryer temperature.

The present invention also provides a method for increasing efficiency of a functional additive, the method comprising: a) forming a wet cellulosic sheet comprising a functional additive; b) drying the wet cellulosic sheet in a dryer to obtain a dry  
10 cellulosic sheet; and c) applying a treatment agent to the dryer; wherein the treatment agent is applied in sufficient quantity to substantially prevent adhesion of the cellulosic sheet to the dryer.

The present invention also provides a method for obtaining a cellulosic sheet, the method comprising: a) forming a wet cellulosic sheet comprising a strength agent; b) applying a treatment agent to a dryer; and c) drying the wet cellulosic sheet in the  
15 dryer to obtain a dry cellulosic sheet; wherein the dry cellulosic sheet is smoother than a cellulosic sheet obtained from the same materials and methods but for at least one of a) and b).

The present invention also provides an improvement in a paper machine and in a paper machine process, the paper machine comprising a wet end and a dryer section,  
20 wherein a wet cellulosic sheet comprising a functional additive is formed in the wet end, the dryer section comprising at least one dryer drum operated at a drying temperature, and the paper machine is operated at a machine speed, the improvement comprising applying a treatment agent to the dryer.

The present invention also provides an improvement in a paper machine and in a  
25 paper machine process, the paper machine comprising a wet end and a dryer section, wherein a treatment agent is applied to the dryer, the dryer section comprising at least one dryer drum operated at a drying temperature, and the paper machine is operated at a machine speed, the improvement comprising forming a wet cellulosic sheet comprising a functional additive in the wet end.

The present invention also provides an improvement in a paper machine, and in a paper machine process, the paper machine comprising a wet end and a dryer section, wherein the paper machine is operated at a machine speed, and the dryer section comprises at least one dryer drum operated at a drying temperature, the improvement comprising: a) applying a treatment agent to the dryer; and b) increasing at least one of the drying temperature and the machine speed.

The functional additive preferably comprises at least one of a strength agent and a sizing agent. The functional additive preferably comprises at least one of a cellulose-reactive agent and a non-cellulose-reactive agent.

10 A strength agent used in the present invention is preferably cellulose-reactive or non-cellulose reactive. Preferred cellulose-reactive strength agents include at least one of a polymer having epoxide functionality and polymer having aldehyde functionality. Preferred cellulose reactive strength agents having epoxide functionality include at least one of polyamido amine epichlorohydrin resin, polyamine epichlorohydrin resin.

15 Preferred cellulose reactive strength agents having aldehyde functionality include at least one of aldehyde starch, glyoxalated polyacrylamide, urea formaldehyde resin, and melamine formaldehyde resin. Preferred non-cellulose-reactive strength agents comprise at least one of latex, latex derivative, starch, starch derivative, gum, gum derivative, carboxymethyl cellulose, polyvinyl alcohol, homopolymer or copolymer of vinylamine,

20 and polyacrylamide.

A sizing agent used in the present invention is preferably cellulose reactive. A functional additive comprising a cellulose reactive sizing agent preferably comprises at least one of a ketene dimer, a ketene multimer, and an alkenyl succinic anhydride. Preferred ketene dimers comprise at least one of an alkyl ketene dimer, an alkenyl ketene dimer, and an aryl ketene dimer.

25

In methods of the present invention, the dryer preferably comprises at least one of a drying fabric and a drying drum, and the treatment agent is preferably applied to the dryer, preferably to at least one of the drying drum and drying fabric. Treatment agents, the same or different, can be applied to any combination of dryer drum(s) and/or dryer



fabric. Thus, where a treatment agent is applied to a drum, a second treatment agent can be applied to another drum, or, if present, to a drying fabric.

A treatment agent for use in the present invention preferably comprises at least one of an oil, a synthetic resin powder, and a combination of cationic and anionic resins.

- 5 A treatment agent comprising an oil is preferably applied to at least one of a dryer drum and a drying fabric. A treatment agent comprising a synthetic resin powder is preferably applied to a dryer drum. A treatment agent comprising a resin is preferably applied to a drying fabric.

- 10 A treatment agent comprising an oil preferably comprises a mineral oil, a natural or derivatized vegetable oil, a natural or derivatized animal oil, or a silicone oil. A treatment agent comprising a derivatized vegetable or animal oil preferably comprises at least one of a partially hydrogenated animal or vegetable oil; a completely hydrogenated animal or vegetable oil; an animal or vegetable oil transesterified with a polyol; and an acetylated animal or vegetable oil.

- 15 A treatment agent comprising a synthetic resin powder preferably comprises melamine cyanurate or polytetrafluoroethylene. Preferred melamine cyanurate comprises melamine cyanurate prepared from about equal weights of melamine and isocyanuric acid. The synthetic resin powder preferably comprises particles having sizes in the range of about 0.1 to 10  $\mu\text{m}$ , more preferably about 1 to 5  $\mu\text{m}$ .

- 20 A surfactant is preferably included in a treatment agent comprising an oil or a synthetic resin powder. A treatment agent comprising an oil preferably comprises an oil-in-water emulsion, and preferably comprises a surfactant. A treatment agent comprising a synthetic resin powder preferably comprises an aqueous dispersion of the synthetic resin powder, and preferably comprises a surfactant. The surfactant preferably  
25 comprises at least one of a nonionic ethoxylated surfactant, an anionic alkyl sulfonate, and a soap.

A treatment agent can be applied continuously or intermittently, preferably continuously.

The rate at which a treatment agent is applied preferably depends on the treatment agent and the dryer surface to which it is applied. A treatment agent comprising an oil applied to a fabric is preferably applied at a rate of about 0.1 to 100 mg oil per m<sup>2</sup> of fabric surface per minute, more preferably about 0.2 to 40 mg oil per m<sup>2</sup> of fabric surface per minute, more preferably about 0.4 to about 20 mg oil per m<sup>2</sup> of fabric surface per minute, more preferably about 0.5 to 10 mg oil per m<sup>2</sup> of fabric surface per minute.

A treatment agent applied to a dryer drum is preferably applied at an average rate greater than about 0.1 to 5000 mg oil per m<sup>2</sup> of drum surface per minute, more preferably about 5 to 1000 mg oil per m<sup>2</sup> of drum surface per minute, more preferably about 30 to 800 mg oil per m<sup>2</sup> of drum surface per minute.

In a treatment agent comprising an oil and applied to a dryer drum, the oil is preferably applied at a rate in the range of about 0.1 to 1000 mg/m<sup>2</sup>/min, more preferably about 5 to 1000 mg/m<sup>2</sup>/min, more preferably about 30 to 800 mg/m<sup>2</sup>/min, where "m<sup>2</sup>" refers to the area of the drum. In a treatment agent comprising a synthetic resin powder and applied to a dryer drum, the synthetic resin powder is preferably applied to the drum at an average rate of about 10 µg to 50 mg per m<sup>2</sup> of drum surface per minute.

When machine speed is adjusted according to the present invention, the machine speed is preferably increased at least about 1%, more preferably at least about 2%, even more preferably at least about 4%. Machine speed can be increased up to about 10%, or more.

When dryer temperature is adjusted according to the present invention, the drying temperature is preferably increased at least about 2%, more preferably at least about 3%, and can be increased up to about 5% or more, based on degrees Kelvin.

## 25 Brief Description of the Drawings

The present invention is further described in the detailed description which follows, in reference to the noted plurality of non-limiting drawings, and wherein:

Figure 1 is a schematic diagram of a method for determining paper machine operating parameters according to the present invention.

### Detailed Description of the Invention

The particulars shown herein are by way of example and for purposes of illustrative discussion of the various embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

10 All percent measurements in this document, unless otherwise stated, are measured by weight based upon 100% of a given sample weight. Thus, for example, 30% represents 30 weight parts out of every 100 weight parts of the sample.

Unless otherwise stated, a reference to a compound or component, includes the compound or component by itself, as well as in combination with other compounds or components, such as mixtures of compounds.

Further, when an amount, concentration, or other value or parameter, is given as a list of upper preferable values and lower preferable values, this is to be understood as specifically disclosing all ranges formed from any pair of an upper preferred value and a lower preferred value, regardless whether ranges are separately disclosed.

20 Before further discussion, a definition of the following terms will aid in the understanding of the present invention.

Many different additives are used in the papermaking process. These can be categorized as functional additives and process improvement additives. Functional additives, as defined in this invention, are additives that, by being incorporated into a cellulosic sheet, impart a new property or enhance a property to the cellulosic sheet. Examples of functional additives by this definition are dyes, sizing agents, and additives that improve strength. A process improvement additive is any additive that either improves the paper making process or processing of the cellulosic sheet. Although a process improvement additive might enhance the properties of a cellulosic sheet, the

additive does not do so through being incorporated in the sheet, but by some other means. Examples of process improvement additives by this definition are foam control products, additives that control microbiological growth in the process water and additives that reduce sheet adhesion to surfaces that contact the cellulosic sheet.

5           Functional additives added to paper can be classified according to many criteria. One classification relevant to the present invention is cellulose reactivity. A cellulose reactive agent is an agent that reacts with cellulose to form a covalent bond. An agent that is not cellulose reactive does not form a covalent bond with cellulose. Even an agent that is not cellulose reactive, however, can form a chemical association with  
10 cellulose, if, for example, the agent is cationic in nature.

As used herein, the terms "latex" or "latices" refer to the natural product itself, as well as latex derivatives and related substances. Latices can be used as non-reactive strength additives to cellulosic products. As is known to those of ordinary skill in the art, latices may be applied to cellulosic products as aqueous emulsions in pulp slurries,  
15 e.g., as an emulsion added to a pulp slurry before sheet formation in a paper machine.

Methods of the present invention are directed toward production of cellulosic products, e.g., paper and paperboard. The inventive methods combine use of a functional additive and at least one process improvement additive applied in the dryer section of a paper machine, which combination provides for more efficient use of a  
20 functional additive. The interplay between functional additive and process improvement additive used in the dryer section is complex, and provides several methods for enhancing productivity. The functional additive applied before sheet formation in the inventive methods preferably comprises a strength and/or sizing agent. The functional additive can comprise additives considered to be cellulose-reactive, not cellulose  
25 reactive, and mixtures thereof. The process improvement additive applied in the dryer section comprises application of a release agent to any combination of dryer fabrics and dryer drums.

Methods of the present invention are also directed toward methods to permit higher drying temperatures. Temperatures of drying drums in a paper machine are

generally between about 50 and 135 °C. The upper temperature is limited by paper ignition temperature and other factors in addition to deposition. Even with perfectly clean drums the temperature generally does not exceed about 135 °C. Higher temperatures are generally associated with increased deposition problems. As the paper dries, however, tendency for deposition reduces. Thus, in dryer sections having more than one drying drum, drum temperatures are typically gradually increased as the paper gets drier. In situations where there is a very bad deposition problem, the first dryer drum is generally operated at a low temperature, or not even heated at all. Because processes according to the present invention reduce or eliminate dryer deposition, it becomes possible to dry paper more aggressively by, e.g., increasing dryer drum temperatures.

The relation between dryer temperature and productivity can vary from machine to machine. As a general rule, however, the higher the drying temperature, the higher the productivity. Processes according to the present invention, therefore, can increase productivity by permitting higher drying temperatures. Productivity can be increased, e.g., by 5% or more, especially in a dryer-limited paper machine.

Thus, it is believed that the present invention permits use of more aggressive drying and/or increased machine speed, thereby reducing the available time in which functional additives subject to hydrolysis, e.g., cellulose-reactive additives, are subject to the hydrolyzing effect of water.

In one aspect of the present invention, there is provided a method for increasing the efficiency of a functional additive by employing a process improvement agent, i.e., treatment agent, in the dryer section of a paper machine. In this aspect there are provided methods for obtaining a greater degree of effect from the same level of functional additive, preferably a cellulose-reactive additive.

In another aspect of the present invention, there is provided a method to obtain a desired level of strength and/or sizing in a paper product, while using a reduced amount of strength and/or sizing agent, by employing process improvement agent, i.e., a treatment agent, in the dryer section of a paper machine. This method increases the yield

of functional additive by providing cleaner drying surfaces, which in turn results in cellulosic products having more uniform water contents, and lower water contents, as it progresses through the dryer. By providing for more uniform and lower water contents, methods of the present invention permit use of lower amounts of functional additive, hence reduced materials costs, to obtain products with the desired characteristics.

In another aspect of the present invention, there is provided a method for increasing drying temperature of the dryer section of a paper machine, by employing process improvement agent, i.e., a treatment agent, in the dryer section of a paper machine. Temperatures can be increased, e.g., at least about 2%, more preferably at least about 3%, more preferably at least about 5% or more, based on degrees Kelvin.

The present invention also provides for a method of producing paper having decreased linting, decreased fiber rising, and/or increased smoothness, by use of a release agent in conjunction with a functional additive comprising a size agent or strength agent.

The method also provides for improved manufacture of paper using increased amounts of latex-based strength additive.

Without wishing to be bound by theory, it is believed that the process improvement agent acts as a release agent in the dryer section of a paper machine, which has two dominant effects on functional additives. First, use of a release agent permits more aggressive drying in the beginning of the dryer section. This allows for more rapid removal of water from the sheet, and easier release of the sheet from dryer drums. By removing water more rapidly, time for side reactions, such as hydrolysis of cellulose reactive agents, is reduced. This, in turn, can either permit higher yield from the amount of functional additive used, or can permit obtaining a target value, e.g., of strength or sizing, using a lower amount of functional additive. Second, it is believed that the process improvement agent maintains a clean dryer section. The consequence of this is improved paper uniformity, e.g., because of improved moisture removal through the dryer fabric. Another likely reason for the improved uniformity is the more uniform heat transfer from a clean dryer drum compared to that from a dryer drum with deposits,

because the deposits act as insulators impairing heat transfer at the location of the roll where the deposit is formed.

Functional additives are applied at a level sufficient to meet the minimum specification. When the paper is non-uniform, the section of the paper with the lowest quality point determines the addition rate. In consequence, all other parts of the paper have an addition rate surplus to the requirement. The more non-uniform the paper is, the greater the difference between the lowest point and the average. The addition rate is most easily targeted to obtain a desired property when the paper is perfectly uniform as it is only in this case every part of the paper is treated with a product at an addition rate required for that particular point. For this reason it is desirable to have as uniform paper as possible.

Further, many additives, such as strength additives, themselves increase the adhesiveness of the cellulosic sheet, e.g., paper, to the dryer roll. By combining the use of strength additive applied before sheet formation with a dryer section process improvement product it is possible to reduce, minimize, or eliminate this sheet adhesion during drying and the consequences of the adhesion such as increased linting and fiber rising.

Functional additives used in processes according to the present invention comprise at least one of a strength agent and a sizing agent.

All additives applied before sheet formation that increase strength in a cellulosic sheet, e.g., paper or paperboard, can be used in methods according to the present invention. In particular, strength agents that may be used include dry strength agents and wet strength agents, the wet strength agents including both temporary and permanent wet strength agents, as well as mixtures thereof. The classification of a strength agent is not important, and it is noted that certain strength agents are known to increase more than one type of strength.

Useful dry strength additives are described in Dry Strength Additives (Walter F. Reynolds editor, TAPPI Press 1980), which is incorporated in its entirety herein by reference.

Strength agents which are natural, or based on natural materials, and which can be used in the present invention include, e.g., natural hemicelluloses of wood; carboxymethyl cellulose; starches; gums, such as plant gums such as guar or locus bean gum; derivatives of these materials, and mixtures thereof.

5 Synthetic strength agents can be used in the present invention. Preferred synthetic strength agents include synthetic hydrophilic polymers, including polyvinyl alcohol, homopolymers or copolymers of polyvinyl amine, polyethylene imine, copolymers of acrylamide, polyamidoamine epichlorohydrin resins, polyamine epichlorohydrin resins.

10 Other useful additives able to impart strength to paper include the variety of adhesive latices. Examples of these include those made from styrene, butadiene, vinyl acetate, acrylic acid, acrylamide, methacrylic acid, butyl acrylate and other monomers used in emulsion copolymerization. Some preferred latices are disclosed in U.S. Patents Nos. 5,824,191, 5,466,336, 4,510,019, and 4,225,383, the disclosures of which are  
15 incorporated by reference in their entirety.

Preferred cellulose-reactive strength agents include strength agents having aldehyde, epoxide, azetidinium, or other cellulose-reactive functionality. Preferred cellulose-reactive strength agents having aldehyde functionality include aldehyde starches and gums. Preferred synthetic cellulose-reactive strength agents include epoxide-  
20 containing resins; polyamido amine epichlorohydrin resins; polyamine epichlorohydrin resins; urea formaldehyde resins; and melamine formaldehyde resins. Mixtures of cellulose reactive strength agents may also be used. Some preferred cellulose-reactive strength agents are disclosed in U.S. Patents Nos. 4,741,804, 4,731,162, 4,703,116, and 4,675,394, the disclosures of which are incorporated by reference in their entirety.

25 Strength agents which are not cellulose reactive may also be used, and preferably comprise strength agents that are cellulose substantive, e.g., strength agents having a net cationic charge in water which causes them to be attracted to cellulose. Preferred strength agents include latices; natural or derivatized starches, preferably cationic starches; natural or derivatized gums, preferably cationic gums; non-aldehyde-containing



polyacrylamides; homopolymers and copolymers of vinyl amine; and polyvinyl alcohol. Some preferred non-cellulose-reactive strength agents are disclosed in, e.g., U.S. Patents Nos. 5,098,521 and 4,421,602, the disclosures of which are incorporated by reference in their entireties. Also anionic polymers can be used such as carboxymethyl cellulose and anionic urea formaldehyde resins can be used if these are applied together with a cationic material, such as alum or a cationic polymer, that will retain the anionic strength additive to the cellulose fiber at the point of sheet formation. Mixtures of non-cellulose-reactive strength agents can be used in processes of the present invention, as can mixtures of cellulose-reactive and non-cellulose reactive strength agents.

- 10 The amount of strength agent used is preferably an amount sufficient to provide a desired level of strength, or increased strength, in the cellulosic product made. The amount of strength agent used depends on the identity of the strength agent used, and the paper grade produced. The appropriate amounts can be determined by a person of ordinary skill in the art for the particular application. Conventional rates of application
- 15 for some preferred strength agents are provided in Table 1.

TABLE 1

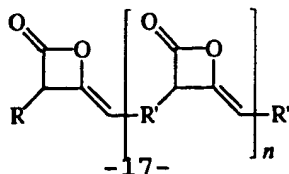
Strength Additive	Conventional Levels of Addition (approximate)
aldehyde starches	0.2-3.0wt%, preferably 0.3-1.0wt%
glyoxalated polyacrylamide	0.1-1.0wt%, preferably 0.2-0.6wt%
epoxide resins	0.1-1.0wt%, preferably 0.2-0.7wt%
polyamido amine epichlorohydrin	0.1-1.0wt%
polyamine epichlorohydrin resins	0.1-1.0wt%
urea formaldehyde resins	0.15-2.0wt%, preferably 0.25-1.0wt%
melamine formaldehyde resins	0.15-2.0wt%, preferably 0.25-1.0wt%

Strength Additive	Conventional Levels of Addition (approximate)
latices	0.2-30wt%, preferably 0.2-10wt%
starches and derivatives	0.2-1.5wt%
natural gums and derivatives	0.1-0.5wt%
polyacrylamides (non-aldehyde)	0.05-0.5wt%
carboxymethyl cellulose	0.05%-0.4wt%
polyvinyl alcohol	0.05-0.4wt%

Methods of the present invention can be used to reduce the amount of strength agent necessary to obtain a desired level of strength. Similarly, methods of the present invention can be used to obtain greater strength from the same level of additive. Further, methods of the present invention can be used to permit use of higher levels of strength agent than was previously feasible.

When a functional additive comprising a sizing agent is used in a process according to the present invention, any sizing agent may be used, preferably a cellulose-reactive size. Preferred cellulose reactive sizes include ketene dimers and multimers, alkenylsuccinic anhydrides, styrene maleic anhydrides, organic epoxides containing from about 12 to 22 carbon atoms, acyl halides containing from about 12 to 22 carbon atoms, fatty acid anhydrides from fatty acids containing about 12 to 22 carbon atoms, and organic isocyanates containing from about 12 to 22 carbon atoms. Preferably, cellulose-reactive sizes used in processes of the present invention comprise alkyl ketene dimers, alkyl ketene multimers, and/or alkenylsuccinic anhydrides. Mixtures of sizing agents, preferably including at least one cellulose-reactive sizing agent, are also included in processes of the current invention.

Ketene dimers and multimers are materials of Formula I:



wherein  $n$  is an integer of about 0 to about 20; R and R", which may be the same or different, are saturated or unsaturated straight chain or branched alkyl groups having 6 to 24 carbon atoms; and R' is a saturated or unsaturated straight chain or branched alkyl group having from about 2 to about 40 carbon atoms.

- 5 Ketene dimers have the structure of Formula I where  $n=0$ . Ketene dimers suitable for use in the present invention preferably include those in which the R and R" groups, which can be the same or different, are hydrocarbon radicals. Preferably, the R and R" groups are alkyl or alkenyl groups having 6 to 24 carbon atoms, cycloalkyl groups having at least 6 carbon atoms, aryl having at least 6 carbon atoms, aralkyl having at least 7 carbon atoms, alkaryl having at least 7 carbon atoms, and mixtures thereof.
- 10 More preferably ketene dimer is selected from the group consisting of (a) octyl, decyl, dodecyl, tetradecyl, hexadecyl, octadecyl, eicosyl, docosyl, tetracosyl, phenyl, benzyl,  $\beta$ -naphthyl, and cyclohexyl ketene dimers, and (b) ketene dimers prepared from organic acids selected from the group of montanic acid, naphthenic acid, 9,10-decylenic acid,
- 15 9,10-dodecylenic acid, palmitoleic acid, oleic acid, ricinoleic acid, linoleic acid, eleostearic acid, naturally occurring mixtures of fatty acids found in coconut oil, babassu oil, palm kernel oil, palm oil, olive oil, peanut oil, rape oil, beef tallow, lard, whale blubber, and mixtures of any of the above named fatty acids with each other. Most preferably, ketene dimer is selected from the group of octyl, decyl, dodecyl, tetradecyl,
- 20 hexadecyl, octadecyl, eicosyl, docosyl, tetracosyl, phenyl, benzyl,  $\beta$ -naphthyl, and cyclohexyl ketene dimers.

- Suitable ketene dimers are disclosed in U.S. Patent No. 4,279,794, and in United Kingdom Patent Nos. 903,416; 1,373,788 and 1,533,434, and in European Patent Application Publication No. 0,666,368 A3, corresponding to commonly owned U.S.
- 25 Patent No. 5,685,815, all of which are incorporated herein by reference in their entireties.

Ketene multimers for use in the process of this invention are disclosed in commonly owned U.S. Patent No. 5,846,663, which is incorporated herein in its entirety. They have the formula I where  $n$  is an integer of at least 1, R and R", which may be the

same or different, are saturated or unsaturated straight chain or branched alkyl group having 6 to 24 carbon atoms; preferably 10 to 20 carbon atoms, and more preferably 14 to 16 carbon atoms; and R' is a saturated or unsaturated straight chain or branched alkyl group having from 20 to 40 carbon atoms, preferably from 4 to 8 or from 28 to 40 atoms. Ketene multimers are also described in EP 0,629,741 A1, incorporated herein in its entirety, and EP 0,666,368 A3, which corresponds to U.S. Patent No. 5,685,815.

Liquid ketene dimers and multimers suitable for use in this invention are disclosed in U.S. Patent No. 5,879,814, which is incorporated herein by reference in its entirety, and U.S. Patents Nos. 5,685,815 and 5,846,663.

Alkyl ketene dimers are commercially available, as Aquapel<sup>®</sup> sizing agents, and in the dispersion form as Hercon<sup>®</sup> emulsion sizes from Hercules Incorporated, Wilmington, Delaware. Ketene dimers not solid at 25° C are available as Precis<sup>®</sup> sizing agents, also from Hercules Incorporated.

Also included in the group of cellulose reactive sizes are alkenylsuccinic anhydrides (ASA). ASAs are composed of unsaturated hydrocarbon chains containing pendant succinic anhydride groups. They are usually made in a two-step process starting with alpha olefin. The olefin is first isomerized by randomly moving the double bond from the alpha position. In the second step the isomerized olefin is reacted with maleic anhydride to give the final ASA structure 2. Typical olefins used for the reaction with maleic anhydride include alkenyl, cycloalkenyl and aralkenyl compounds containing from 8 to about 22 carbon atoms. Specific examples are isooctadecenyl succinic anhydride, n-octadecenyl succinic anhydride, n-hexadecenyl succinic anhydride, n-dodecyl succinic anhydride, i-dodecenyl succinic anhydride, n-decenyl succinic anhydride and n-octenyl succinic anhydride.

Alkenylsuccinic anhydrides are disclosed in U.S. Patent No. 4,040,900, which is incorporated herein by reference in its entirety, and by C.E. Farley and R. B. Wasser in *The Sizing of Paper, Second Edition*, edited by W. F. Reynolds, Tappi Press, 1989, pages 51-62. A variety of alkenylsuccinic anhydrides is commercially available from Albemarle Corporation, Baton Rouge, Louisiana.

The amount of cellulose-reactive size used is preferably an amount sufficient to provide a desired level of sizing, or increased sizing, in the cellulosic product made. Ketene dimers (AKDs), ketene multimers (AKMs), and succinic anhydrides (ASAs), are conventionally added at about 0.05–0.4wt%, more often about 0.05–0.2 wt%, based on weight of dry paper.

Methods of the present invention can be used to reduce the amount of reactive size necessary to obtain a desired level of sizing. Similarly, methods of the present invention can be used to obtain greater sizing from the same level of additive. Further, methods of the present invention can be used to permit use of higher levels of sizing agents than was previously feasible.

Methods according to the present invention employ dryer pacification of depositable substances. While any method of dryer pacification can be used, it is preferred to use the methods disclosed in Japanese Patent Applications Nos. 10/288934, 10/288942, and 10/288945, filed September 25, 1998, and methods disclosed in U.S.

Patent No. 5,246,548, the disclosures of which are incorporated by reference in their entireties. These methods are directed toward spraying of a treatment agent on the dryer of a paper machine. In order to prevent deposition on a dryer fabric, a dryer fabric is preferably sprayed with a treatment agent comprising an oil and/or combination of cationic and anionic polymers. In order to prevent deposition on a dryer drum, a dryer drum is preferably sprayed with a treatment agent comprising an oil, a synthetic resin powder, or a combination thereof. In preferred embodiments, a treatment agent is sprayed onto a dryer fabric and a second treatment agent, optionally the same as the first treatment agent, is sprayed onto a dryer drum.

When treatment agent is applied to the dryer, the heat of the dryer generally evaporates most or all of water or other volatiles that may be present, and the remainder of the treatment agent forms a film on a dryer surface, preferably a dryer fabric and/or dryer drum. As paper goes through the dryer, that is, as paper is dried, some of the treatment agent is removed with the paper, which eventually depletes the amount of treatment agent on a dryer surface. Treatment agent should be replenished, therefore,

preferably at a rate approximately equal to the rate of treatment agent depletion. Thus, treatment agent is preferably applied to the dryer, preferably by spraying, either continuously or intermittently. Intermittent application can be at regular or irregular intervals. By "intermittent" is meant, e.g., applying for 15 minutes every 30 or 60  
5 minutes, spraying for 10 minutes every hour, or spraying for several minutes whenever it is determined that treatment levels have sufficiently declined. An appropriate treatment agent and an appropriate treatment agent addition rate can be determined by one of ordinary skill in the art based on the present disclosure.

In conventional dryer treatment methods, in which fabrics and/or drums are  
10 treated with a treatment agent during a machine downtime, there is a gradual depletion of treatment agent, which leads to gradual increase in deposition of depositable substances on dryer surfaces. By continuous or intermittent application of treatment agent, however, prevention of deposition of depositable substances can be maintained over extended periods of paper machine operations. Accordingly, the surface of the  
15 dryer fabric is always in a condition where a suitable amount of the actives contained in the surface treatment agent is present, enabling the fabric to withstand continuous operation satisfactorily.

Different chemical treatments can be used to reduce deposition in a dryer section. Such chemical treatments can be applied in the form of a solution, in a solvent, as a  
20 dispersion, or as neat material, and can be classified as oils, synthetic resin powders, and mixtures thereof.

Several factors should be considered when selecting which treatment agent to use. One factor is the release performance of the treatment agent, i.e., how well the treatment agent prevents deposition on the dryer surface. Another factor is film stability,  
25 i.e., how well the treatment agent maintains as a film under the dryer conditions, especially dryer temperature. Another factor is chemical stability, i.e., how chemically stable the treatment agent is, especially with regard to pH and furnish additives. Another factor is chemical interaction with contaminants, i.e., how stable the treatment agent is with regard to pitch and/or stickies. Yet another factor is adhesiveness, i.e., the

treatment agent should not be adhesive enough to pick up fibers from the wet sheet at dryer surface temperatures. The final factor is impact on the sheet, i.e., the treatment agent should not have an adverse effect on sheet properties at the application rate, especially on sizing and color.

5 Preferred oils include silicones and triglycerides. Preferred silicone oils include dialkylsilicones, alkylaryl silicones, and amino silicones. Examples of these include, but are not limited to, methylphenyl silicone oil, dimethyl silicone oil, denatured amino silicone oil, denatured epoxy silicone oil, denatured higher fatty acid silicone oil. Triglycerides or other oily materials, e.g., natural or hydrogenated vegetable or animal  
10 oil, e.g., castor oil, can also be used. Mineral oils can also be used.

As used in regard to a treatment agent, the term "oil" should be understood to mean that the active ingredient is a liquid at temperatures of use, e.g., at the temperature of the surface in the dryer section to which treatment agent is applied. Similarly, the term "synthetic resin powder" should be understood to refer to a material which is solid  
15 at those temperatures. Thus, for example, because dryers are typically operated at temperatures greater than 100 °C, a paraffin wax having a melting temperature of about 60 °C would be considered an oil rather than a solid.

Examples of commercial treatment agents include a variety of treatment agents from Maintech, Co. Ltd. (Tokyo, Japan), for example, Dusclean liner board Nos. 1 and  
20 2, Dusclean white board Nos. 1, 2 and 4, Dusclean corrugating medium Nos. 1, 2, and 3, Dusclean calendar Nos. 1 and 2, Dusclean fine paper No. 1, Dusclean newsprint Nos. 1, 2, and 3, Cleankeeper E, Cleankeeper S, and Cleankeeper LF treatment agents. Hercules Incorporated (Wilmington, Delaware, USA) has Zenix DS 7148, Zenix DS 7141, Zenix DS 7149 and Zenix DS 7151 treatment agents.

25 The treatment agent can be applied in any manner determined by one of ordinary skill in the art, and is preferably applied by spraying the treatment agent on to the dryer surface to be treated. An oil, e.g., a silicone oil, can be sprayed as a solution, or in the form of an emulsion. A treatment agent comprising an oil is preferably applied with the oil in the form of an emulsion as this lowers viscosity of the treatment agent, and

improves dispersion characteristics during spraying. When a treatment agent comprises an oil in the form of an emulsion, the oil is preferably emulsified with surfactant, by methods determined by those of ordinary skill in the art. Where the oil has surfactant properties, an additional surfactant can be used.

- 5           Any amount of surfactant, or mixture of surfactants, that permits formation of an emulsion by a method determined by one of ordinary skill in the art may be used. Preferred surfactants include anionic and nonionic surfactants. Preferably, a nonionic surfactant comprises ethoxylated surfactants, preferably including at least one of ethoxylated glycerides, ethoxylated fatty acids, or other ethoxylated polyols, such as
- 10 polysorbate 80. When a surfactant comprises an anionic surfactant, the anionicity preferably arises from either a carboxylic acid functionality or a sulfonate functionality. Preferred anionic surfactants include soaps, e.g., sodium or potassium salts of C<sub>10</sub>-C<sub>22</sub> fatty acids, and alkyl sulfonates, e.g., C<sub>10</sub>-C<sub>22</sub> alkyl sulfonates.

The surfactant used for emulsification of oil is preferably present at about 15 to 15-70 wt% of the oil, e.g., silicone oil. Emulsions of oil in water can be prepared in any concentration determined useful by one of ordinary skill in the art. Emulsions preferably have weight ratios of water to oil in the range of about 4 to 15.

- It should be noted that an excessive supply rate of oil in a treatment agent can result in clogging of the openings of the dryer fabric, thereby deteriorating drying
- 20 efficiency; can result in dripping or pooling on drums, leading to waste of material; and can possibly result in excessive pick-up of treatment agent on paper, causing change or variation in paper quality. On the other hand, with an insufficient supply rate of oil, a depleted amount of oil on the fabric and/or drum cannot be replenished quickly enough. An oil treatment rate can vary depending on, e.g., the type of the dryer fabric and/or
- 25 dryer drum, and quality of the paper strip, and can be determined by one of ordinary skill in the art. Whenever a treatment rate is for non-constant or non-continuous treatment, then the treatment rate should be understood as referring to average treatment rate.

The treatment rate for a dryer fabric can be determined by one of ordinary skill in the art, and can depend on the surface area of the fabric, the material from which the



fabric is made, and other factors. As a general rule, the oil in a treatment agent applied to a dryer fabric is preferably applied at a rate greater than about  $0.1 \text{ mg/m}^2/\text{min}$ , more preferably greater than about  $0.2 \text{ mg/m}^2/\text{min}$ , more preferably greater than about  $0.4 \text{ mg/m}^2/\text{min}$ , more preferably greater than about  $0.5 \text{ mg/m}^2/\text{min}$ , and more preferably greater than about  $1 \text{ mg/m}^2/\text{min}$ , where " $\text{m}^2$ " refers to the area, square meters, of fabric, i.e., for a simple closed loop of fabric, the area is simply length times width. Generally, the oil in a treatment agent is applied to a dryer fabric at a rate less than about  $100 \text{ mg/m}^2/\text{min}$ , preferably less than about  $50 \text{ mg/m}^2/\text{min}$ , more preferably less than about  $40 \text{ mg/m}^2/\text{min}$ , more preferably less than about  $25 \text{ mg/m}^2/\text{min}$ , more preferably less than about  $20 \text{ mg/m}^2/\text{min}$ , and more preferably less than about  $10 \text{ mg/m}^2/\text{min}$ .

As a general rule, the oil in a treatment agent applied to a dryer drum is preferably applied at a rate greater than about  $0.1 \text{ mg/m}^2/\text{min}$ , preferably greater than about  $0.5 \text{ mg/m}^2/\text{min}$ , more preferably greater than about  $1 \text{ mg/m}^2/\text{min}$ , more preferably greater than about  $2 \text{ mg/m}^2/\text{min}$ , more preferably greater than about  $5 \text{ mg/m}^2/\text{min}$ , more preferably greater than about  $10 \text{ mg/m}^2/\text{min}$ , more preferably greater than about  $30 \text{ mg/m}^2/\text{min}$ , where " $\text{m}^2$ " refers to the surface area, square meters, of dryer drum, i.e.,  $\pi(\text{drum length})(\text{drum diameter})$ . Generally, the oil in a treatment agent is applied to a dryer fabric at a rate less than about  $5000 \text{ mg/m}^2/\text{min}$ , preferably less than about  $1000 \text{ mg/m}^2/\text{min}$ , preferably less than about  $800 \text{ mg/m}^2/\text{min}$ , more preferably less than about  $500 \text{ mg/m}^2/\text{min}$ , more preferably less than about  $300 \text{ mg/m}^2/\text{min}$ , more preferably less than about  $200 \text{ mg/m}^2/\text{min}$ .

The treatment agent can be diluted with water to any concentration of actives (non-aqueous components) determined by a person of ordinary skill in the art to be used in a particular paper machine, and can depend on the nature of the pulp, other additives used, etc. Preferably, however, the treatment agent sprayed onto the dryer has greater than about  $0.033 \text{ wt\%}$  actives, more preferably greater than about  $1 \text{ wt\%}$  actives, and more preferably greater than about  $5 \text{ wt\%}$  actives. Preferably, the treatment agent sprayed onto the dryer has less than about  $60 \text{ wt\%}$  actives, more preferably less than about  $40 \text{ wt\%}$  actives, more preferably less than about  $30 \text{ wt\%}$  actives.

A treatment agent applied to a dryer drum may contain a synthetic resin powder in addition to, or in place of, an oil. Any synthetic resin powder of appropriate size and type to reduce the effects of asperities in a dryer drum can be used. Since the surface of a drum dryer can be heated up to a high temperature (typically in the range of about 50 to 135 °C), however, use of synthetic resin powders stable at dryer temperatures, e.g., not susceptible to denaturation at dryer temperatures, is preferable.

Some preferred synthetic resins for use in treatment agents include, for example, melamine cyanurate (MCA); polytetrafluoroethylene; and combinations thereof. A treatment agent comprising a synthetic resin preferably comprises a melamine cyanurate (MCA), which preferably comprises MCA prepared by reacting about equal weights of melamine and isocyanuric acid.

As it is believed that particles of synthetic resin act to fill up asperities in the dryer drum, particle size is an important consideration in selecting a synthetic resin powder. Any particle size distribution that is capable of efficiently filling up asperities in a dryer roll may be used in methods of the present invention, and can be determined by one of ordinary skill in the art for the particular equipment used. If the particle size is too small, the fill-up condition becomes unstable, and if the particle size is too large, it becomes difficult to fill up the recesses in the microscopic asperities on the surface of the drum dryer.

From the viewpoint of achieving high efficiency in filling up recesses in microscopic asperities on the surface of the drum dryer, synthetic resin powders will generally have average particle sizes greater than about 0.1  $\mu\text{m}$ , more preferably greater than about 1  $\mu\text{m}$ . Generally, the synthetic resin powders will have average particle sizes less than about 10  $\mu\text{m}$ , more preferably less than about 5  $\mu\text{m}$ .

An application rate of synthetic resin powder may be determined by a person of ordinary skill in the art to deliver a sufficient amount of powder to the drum surface, and may depend on a number of factors, including, for example, on the average particle size in the resin powder, on the material and condition of the drum to which the treatment is applied, and the method of application. It is preferable to spray a treatment agent

comprising a synthetic resin powder on the surface of the dryer, preferably at a low rate of application. Preferably, the rate of application is greater than about  $2 \mu\text{g}/\text{m}^2/\text{min}$ , more preferably greater than about  $10 \mu\text{g}/\text{m}^2/\text{min}$ , more preferably greater than about  $30 \mu\text{g}/\text{m}^2/\text{min}$  based on the weight of the resin powder and the drum surface area. The  
5 rate of application is preferably less than about  $50 \text{ mg}/\text{m}^2/\text{min}$ , more preferably less than about  $10 \text{ mg}/\text{m}^2/\text{min}$ .

It is preferable that the treatment agent comprising a synthetic resin powder also comprise a surfactant to improve the quality of the dispersion, so that spraying as described hereinafter can be facilitated. Any surfactant that improves the dispersion can  
10 be used. Preferable surfactants include anionic and nonionic surfactants. Preferably, a nonionic surfactant comprises ethoxylated surfactants, preferably including at least one of ethoxylated glycerides, ethoxylated fatty acids, or other ethoxylated polyols, such as polysorbate 80. When a surfactant comprises an anionic surfactant, the anionicity preferably arises from either a carboxylic acid functionality or a sulfonate functionality.  
15 Preferred anionic surfactants include soaps, e.g., sodium or potassium salts of  $\text{C}_{10}$ – $\text{C}_{22}$  fatty acids, and alkyl sulfonates, e.g.,  $\text{C}_{10}$ – $\text{C}_{22}$  alkyl sulfonates.

When present, surfactant preferably represents about 15 to 60 wt% based on the total of surfactant and synthetic resin powder. A treatment agent comprising a dispersion of synthetic resin powder generally contains about 5 to 100 times as much  
20 water (by weight) as much as the synthetic resin powder or sum of synthetic resin powder and surfactant.

Whether a treatment agent comprises an oil, a synthetic resin powder, or both, water used for dilution and/or application is preferably heated to a temperature in the range of 50 to 80 °C to minimize a risk of the nozzles getting clogged, e.g., with scum  
25 and slime. In this case, the surface treatment agent is preferably also heated to a substantially equivalent temperature.

Further, in actually supplying the surface forming agent onto the surface of the dryer, a spray nozzle or spray nozzles are preferably employed. In order to prevent spray nozzles from getting clogged, the treatment agent may be further diluted with

water (on the order of 10-to 100-fold) before the treatment agent is applied to a dryer surface.

Treatment agents for use in the present invention may also contain other additives as deemed necessary by one of ordinary skill in the art to control or modify the treatment agent. These may include, for example, preservatives, antistatic agents, viscosity modifiers, and mixtures thereof.

Further, a treatment agent can comprise ingredients to alter the characteristics of the paper product produced. Depending on the type of paper product being manufactured, such ingredients include, for example, lipid (including oil or solid wax) based dusting inhibitor.

A treatment agent can be applied to a dryer by any means. The method of application is not important as long as the treatment is evenly applied to the surface which is to be treated, e.g., a dryer drum or dryer fabric. A preferred method of application is with spray nozzles.

Several different methods of spraying a treatment onto a dryer are available, and can vary; for example in the number of spray nozzles and whether the nozzles are stationary or traversing nozzles. Stationary nozzles are generally employed in one of two ways. First, there can be two jets, one situated on each outer edge of the width of the drum or fabric to be treated. Second, there can be a multiplicity of nozzles arranged across a width of drum or fabric to be treated. When treatment agent is pumped through the jets, or through the nozzles, the treatment agent is sprayed approximately uniformly across surface to be sprayed, e.g., the width of drum or fabric.

In contrast to stationary nozzles, with traversing nozzles, one or more nozzles are mounted on tracks which permit the nozzles to traverse the width of the surface to be sprayed, thereby covering the entire width of the surface to be sprayed.

Combinations of stationary and/or traversing nozzles can also be used.

Any spraying apparatus, whether commercially available or custom made, can be used. Preferred spraying apparatuses are manufactured by Maintech Co. Ltd, Tokyo, Japan under the trade names MISTRUNNER, CLEAN HIT and SPRAY BAR.

MISTRUNNER comprises a single traversing spray nozzle. CLEAN HIT comprises two types of stationary nozzles; a needle nozzle to spray the center part of the fabric or drum, and fan nozzles to spray from each end. SPRAY BAR comprises a plurality of stationary nozzles. Each of these apparatuses can be obtained with heating and mixing units for the treatment agent.

When a treatment agent is applied to a dryer fabric, it is applied either directly, e.g., by spraying the fabric, or indirectly, e.g., by applying the treatment agent to a roll that contacts the fabric. It is preferred to apply treatment agent to a fabric either by a single traversing nozzle, or with two jet nozzles.

In order to permit water a chance to substantially completely evaporate, treatment agent applied to a fabric is preferably applied to the fabric at a location distant from where the fabric contacts the paper, such as at the stretch roll. It is also preferable to apply a treatment agent to the side of the fabric that comes in contact with the paper, or to a roll that contacts the side of the fabric that contacts the paper.

When a treatment agent is to be applied to a dryer drum, the treatment agent is preferably applied directly to the drum with a single traversing nozzle. Evaporation is less of a consideration when spraying a drying drum than when treating a fabric because the high heat of the drying drum results in rapid evaporation of water that may be present in the treatment agent.

In one aspect of the present invention parameters for operation of a paper machine can be determined by following the methodology that is schematically represented in Figure 1. When two or more paper mills have similar equipment and/or produce similar papers, it is also possible to follow the methodology in one mill, and apply the results in other mills.

The first step is determining whether to implement a dryer section treatment program. This determination involves at least one of three inquiries which can be made by a person of ordinary skill in the art.

The first inquiry is whether paper nonuniformity should be improved. Nonuniformity in this context refers to any nonuniformity that is desirable to reduce or

eliminate, and includes, for example, nonuniform cross direction moisture profile. The second inquiry is whether fiber rising should be reduced. The third inquiry is whether higher temperatures can or should be used in the dryer section, or whether a higher machine speed is desired.

- 5           The first two inquiries can involve consideration of a number of factors, including, e.g., the paper grade being manufactured and customer requirements. The third inquiry is generally based at least partially on the capabilities of the paper machine.

- If the answer to any of these inquiries is yes, then the second step of the method should be undertaken. The second step is determining whether treatment agent in the  
10   dryer section can be used to improve paper machine operations, and implementing such a treatment program. This determination includes attributing, at least in part, any paper characteristic sought to be improved to a problem in the dryer section. Thus, for example, if fiber rising is more of a problem on one side of a sheet than another, perhaps only the set of dryer drums contacting that side need be treated. If paper nonuniformity  
15   is the problem, and an examination of the dryer reveals clean dryer drums but a partially clogged dryer fabric, then at least the dryer fabric will need to be treated.

- With a treatment program planned or in place, the third step is parameter adjustment, for performance improvement. The addition rate of functional additive, the dryer drum temperature, the machine speed, or any combination thereof, can be adjusted.  
20   When the functional additive addition rate is adjusted, this will generally involve reducing the amount of functional additive to nevertheless obtain about the same paper quality as before adjustment. Alternatively, the amount of functional additive can be maintained or increased to obtain paper with enhanced qualities compared to before adjustment. When dryer drum temperature is adjusted, this generally means that dryer  
25   drum temperature is increased to a level closer to, or about at, the maximum operational temperature of the machinery. When machine speed is increased, this generally means an increase in machine speed.

          The person of ordinary skill in the art is able to address each determination and inquiry in the above method without undue experimentation.

Methods of the present invention can be applied either retrospectively or prospectively. By retrospective application is meant that parameters are analyzed retrospectively, e.g., based on past paper machine performance. By prospective application is meant that the parameters are based on operating changes that a paper machine operator would like to implement, such as, for example, increasing machine speed.

Employing methods of the present invention requires measuring or estimating a number of variables and parameters, and requires that decisions be made. It will be understood by one of ordinary skill in the art that each measurement, estimation, and decision can be made by a person through mental processes, can be made by a computer, or can be made by a combination of mental processes and computer calculations.

#### Examples

The present invention is further illustrated by way of the following contemplative examples, which, for one of ordinary skill in the art, suffice to illustrate parameter adjustment processes and paper making machine operations according to the present invention. These examples are non-limiting and do not restrict the scope of the invention.

Unless stated otherwise, all percentages, parts, etc. presented in the examples are by weight.

#### Example 1

A newsprint producer using 80% deinked waste paper and 20% thermomechanical pulp experiences problems with linting for a paper grade that also contains 2% filler added to give the paper increased opacity. Addition of 5 lb. per ton of cationic starch prior to sheet formation is used to provide internal strength and to increase surface strength. The starch addition reduces the fiber and filler linting caused by insufficient surface strength to some extent but not sufficiently to eliminate the problem with lint accumulation during printing. Continuous application of a treatment agent comprising on the first and second drying drums as per the invention reduces the linting further and to a level where it was no longer considered a problem. The increased

release also reduces the stretch of the paper in the drying section. The treatment agent comprises an oil-in-water emulsion comprising about 20wt% paraffin wax having a melting point about 50 °C, about 3wt% alkyl sulfonate surfactant, and about 77wt% water manufactured by applying high shear created by a turbine mixer on a coarse  
5 emulsion of all components at a temperature of 65 °C, then cooling to ambient temperature. The treatment agent, at ambient temperature, is applied to the first heated dryer drum coming in contact with each side of the paper (i.e., applied to two drums) by a MISTRUNNER traversing atomizing nozzle at an addition rate of 10 ml/min for each application point. The drying drums, which are maintained at 120 °C, are 8 m in width,  
10 and have 1.8 m diameters.

Because of the improved release effected by application of the treatment agent, the internal sheet strength requirement increases in importance relative to the surface strength requirement as a factor for determining an effective level of starch addition. Thus, the mill can now choose between two different approaches for further parameter  
15 adjustment. It can reduce the addition rate of cationic starch as the addition rate is now determined by the internal strength requirement, or it could maintain the addition rate but increase the filler level. The process manager for this mill decides that rather than reduce cost by reducing the addition rate of cationic starch, it would be more advantageous for the mill to increase the level of filler further, as this would increase the quality (e.g.,  
20 improved opacity) of the paper.

#### Example 2

A fine paper machine using bleached hardwood fibres and 18% precipitated calcium carbonate (PCC) is sizing the paper with 2 lb. ton of alkyl ketene dimer reactive size. In addition, the mill was also used 10 lb./ton of cationic starch for internal strength.  
25 Due to the presence of starch in the furnish there is considerable fiber rising in the drying section. The mill process manager is only able to minimize the fiber rising by drying the paper very gently in the first part of the drying section by operating the first six drying drums at about 30 °C below the machine's maximum operating temperature, and operating the remaining drums at about the machine's maximum temperature.



Applying a process improvement program in the dryer section consisting of the application of 15 ml/m<sup>2</sup>/min treatment agent comprising a 10% emulsion of a vegetable oil in water onto the first dryer drum allows the mill to dry the paper faster in the beginning of the dryer section by increasing the drying cylinder temperature. This not only increases the productivity of the mill, but also allows the mill to maintain level of sizing while reducing the addition rate of sizing agent by 20% as loss of sizing agent in the drying section, attributable to hydrolysis in the competing reaction with water, is reduced.

### Example 3

10 A production manager in a paper mill producing newsprint receives complaints of excessive linting from a converter of the newsprint. The newsprint is prepared from a furnish made of 98% de-inked newsprint and 2% clay. Cationic starch (5 kg/ton paper) is added for strength. Cationic polyacrylamide (200 g/ton paper) is added as a retention agent. An examination of the newsprint leads the manager to attribute the linting in the newsprint to fiber rising on both sides of the newsprint. Upon examining the machinery, the manager notices linting on the dryer drums, but little clogging of the dryer fabric. The production manager decides to implement a dryer section treatment program to reduce fiber rising. A composition prepared and applied to the first dryer drum to contact each side of the newsprint as in Example 1. The dryer drums are each 8 m in width, and 1.8 m in diameter. The composition is applied continuously at a rate of 10 ml/min.

The production manager then finds that because of reduced adhesion to the dryer drums, the amount of strength agent used can be reduced by 20% to obtain newsprint sufficiently strong and lint-free to satisfy the customer.

25 While the invention has been described in connection with certain preferred embodiments so that aspects thereof may be more fully understood and appreciated, it is not intended to limit the invention to these particular embodiments. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the scope of the invention as defined by the appended claims.

## Claims

What is claimed is:

1. A method for adjusting parameters in a paper machine comprising a dryer section  
5 and producing a cellulosic product from a fiber furnish comprising a functional additive,  
the method comprising:
  - a) deciding whether to implement a dryer section treatment program;
  - b) if yes, then determining what dryer section treatment program to use;
  - c) implementing a dryer section treatment program; and
  - 10 d) adjusting at least one paper machine parameter based on the dryer section  
treatment program.
2. The method of claim 1 wherein the dryer section comprises at least one of a dryer  
15 drum and a drying fabric, and the implementing comprises application of a  
treatment agent to at least one of the dryer drum and the dryer fabric.
3. The method of claim 1 wherein the adjusting comprises at least one of:
  - d1) adjusting the amount of functional additive; and
  - d2) adjusting dryer temperature.
- 20 4. The method of claim 3 wherein the dryer section comprises at least one of a dryer  
drum and a drying fabric, and the implementing comprises applying a treatment agent to  
at least one of the dryer drum and the dryer fabric.
- 25 5. The method of claim 1, 2 or 3 wherein the deciding is based on at least one of:
  - a1) deciding to improve paper uniformity;
  - a2) deciding to improve at least one of fiber rising, linting, and smoothness;
  - and
  - a3) deciding to increase dryer section temperature.

6. The method of claim 1, 2 or 3 wherein a treatment agent is selected, and the determining is based on at least one of:

- b1) how well the treatment agent prevents deposition on the dryer surface;
- 5 b2) how well the treatment agent maintains as a film under dryer conditions;
- b3) how chemically stable the treatment agent is;
- b4) how stable the treatment agent is with regard to at least one of pitch and stickies;
- b5) non-adhesiveness of the treatment agent;
- 10 b6) how well the treatment agent avoids adverse effect on sheet properties.

7. The method of claim 5 wherein a treatment agent is selected, and the determining is based on at least one of:

- b1) how well the treatment agent prevents deposition on the dryer surface;
- 15 b2) how well the treatment agent maintains as a film under dryer conditions;
- b3) how chemically stable the treatment agent is;
- b4) how stable the treatment agent is with regard to at least one of pitch and stickies;
- b5) non-adhesiveness of the treatment agent;
- 20 b6) how well the treatment agent avoids adverse effect on sheet properties.

8. The method of claim 4 wherein the deciding is based on at least one of:

- a1) deciding to improve paper uniformity;
- a2) deciding to improve at least one of fiber rising, linting, and smoothness;
- 25 and
- a3) deciding to increase dryer section temperature.

9. The method of claim 4 wherein a treatment agent is selected, and the determining is based on at least one of:

- b1) how well the treatment agent prevents deposition on the dryer surface;
- b2) how well the treatment agent maintains as a film under dryer conditions;
- b3) how chemically stable the treatment agent is;
- b4) how stable the treatment agent is with regard to at least one of pitch and  
5 stickies;
- b5) non-adhesiveness of the treatment agent;
- b6) how well the treatment agent avoids adverse effect on sheet properties.

10. The method of claim 9 wherein the deciding is based on at least one of:
- 10 a1) deciding to improve paper uniformity;
  - a2) deciding to improve at least one of fiber rising, linting, and smoothness;
- and
- a3) deciding to increase dryer section temperature.

- 15 11. A method for increasing efficiency of a functional additive, the method comprising:
- a) forming a wet cellulosic sheet comprising a functional additive;
  - b) drying the wet cellulosic sheet in a dryer to obtain a dry cellulosic sheet;
- and
- 20 c) applying a treatment agent to the dryer;

wherein the treatment agent is applied in sufficient quantity to substantially prevent adhesion of the cellulosic sheet to the dryer.

12. The method of claim 11 wherein the functional additive comprises at least one of  
25 a strength agent and a sizing agent.

13. The method of claim 12 wherein the functional additive comprises a strength agent comprising a cellulose-reactive strength agent.

14. The method of claim 13 wherein the cellulose reactive strength agent comprises at least one of a polymer having epoxide functionality and polymer having aldehyde functionality.

5 15. The method of claim 14 wherein the cellulose reactive strength agent comprises a polymer having epoxide functionality comprising at least one of polyamido amine epichlorohydrin resin, and polyamine epichlorohydrin resin.

16. The method of claim 14 wherein the cellulose reactive strength agent comprises a  
10 polymer having aldehyde functionality comprising at least one of aldehyde starch, glyoxalated polyacrylamide, urea formaldehyde resin, and melamine formaldehyde resin

17. The method of claim 12 wherein the functional additive comprises a strength agent comprising a non-cellulose-reactive strength agent.

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18. The method of claim 17 wherein the non-cellulose-reactive strength agent comprises at least one of latex, latex derivative, starch, starch derivative, gum, gum derivative, carboxymethyl cellulose, polyvinyl alcohol, homopolymer or copolymer of vinylamine, and polyacrylamide.

20

19. The method of claim 17 wherein the strength agent comprises a latex and the latex comprises about 0.2wt.% to 30wt.% based on dry weight of the cellulosic sheet.

20. The method of claim 12 wherein the strength agent comprises a starch, starch  
25 derivative, gum, or gum derivative and the starch, starch derivative, gum, or gum derivative comprises about 0.2wt.% to 1.5wt.% based on dry weight of the cellulosic sheet.

21. The method of claim 12 wherein the functional additive comprises a sizing agent comprising a cellulose reactive sizing agent.
22. The method of claim 21 wherein the cellulose reactive sizing agent comprises at  
5 least one of a ketene dimer, a ketene multimer, and an alkenyl succinic anhydride.
23. The method of claim 22 wherein the ketene dimer comprises at least one of an alkyl ketene dimer, an alkenyl ketene dimer, and an aryl ketene dimer.
- 10 24. The method of claim 11 wherein the dryer comprises at least one of a drying fabric and a drying drum.
25. The method of claim 24 wherein the dryer comprises a drying fabric and the treatment agent is applied to the drying fabric
- 15 26. The method of claim 24 wherein the dryer comprises a drying drum and the treatment agent is applied to the drying drum.
27. The method of claim 26 wherein the dryer comprises a drying fabric, and a  
20 second treatment agent is applied to the drying fabric.
28. A method for obtaining a cellulosic sheet, the method comprising:
- a) forming a wet cellulosic sheet comprising a strength agent;
  - b) applying a treatment agent to a dryer; and
  - 25 c) drying the wet cellulosic sheet in the dryer to obtain a dry cellulosic sheet;
- wherein the dry cellulosic sheet is smoother than a cellulosic sheet obtained from the same materials and methods but for at least one of a) and b).

29. The method of claim 28 wherein the dryer comprises a dryer fabric and a drum, and the treatment agent is applied to at least one of the dryer fabric and drum.

30. The method of claim 29 wherein the treatment agent comprises an oil.

5

31. The method of claim 30 wherein the oil comprises a mineral oil, a natural or derivatized vegetable oil, a natural or derivatized animal oil, or a silicone oil.

32. The method of claim 31 wherein the derivatized vegetable of animal oil comprises at least one of a partially hydrogenated animal or vegetable oil; a completely hydrogenated animal or vegetable oil; an animal or vegetable oil transesterified with a polyol; and an acetylated animal or vegetable oil.

10

33. The method of claim 29 wherein the treatment agent is applied to the dryer fabric.

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34. The method of claim 29 wherein the treatment agent is applied to the drum.

35. The method of claim 34 wherein the treatment agent comprises an oil.

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36. The method of claim 35 wherein the treatment agent comprises an oil-in-water emulsion.

37. The method of claim 36 wherein the treatment agent comprises a surfactant.

25

38. The method of claim 37 wherein the surfactant comprises at least one of a nonionic ethoxylated surfactant, an anionic alkyl sulfonate, and a soap.

39. The method of claim 38 wherein the treatment agent is applied to the drum at an average rate of about 0.1 to 1000 mg oil per m<sup>2</sup> of drum surface per minute.

5 40. The method of claim 39 wherein the treatment agent is applied to the drum continuously.

41. The method of claim 39 wherein the treatment agent is applied to the drum intermittently.

10 42. The method of claim 35 wherein the oil comprises a mineral oil, a natural or derivatized vegetable oil, a natural or derivatized animal oil, or a silicone oil.

43. The method of claim 35 wherein the treatment agent further comprises a synthetic resin powder.

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44. The method of claim 34 wherein a second treatment agent comprising an oil is applied to the dryer fabric.

20 45. The method of claim 34 wherein the treatment agent comprises a synthetic resin powder.

46. The method of claim 45 wherein the treatment agent comprises an aqueous dispersion of the synthetic resin powder.

25 47. The method of claim 45 wherein the synthetic resin powder is applied to the drum at an average rate of about 10 µg to 50 mg per m<sup>2</sup> of drum surface per minute.

48. The method of claim 47 wherein the treatment agent is applied to the drum continuously.



49. The method of claim 47 wherein the treatment agent is applied to the drum intermittently.
- 5 50. The method of claim 45 wherein the synthetic resin powder comprises a melamine cyanurate or a polytetrafluoroethylene.
51. The method of claim 50 wherein the melamine is prepared from about equal weights of melamine and isocyanuric acid.
- 10 52. The method of claim 45 wherein the synthetic resin powder comprises particles having sizes in the range of about 0.1 to 10  $\mu\text{m}$ .
53. The method of claim 52 wherein the synthetic resin powder comprises particles having sizes in the range of about 1 to 5  $\mu\text{m}$ .
- 15 54. The method of claim 29 wherein the treatment agent comprises an anionic resin and a cationic resin.
- 20 55. The method of claim 54 wherein the treatment agent is applied to the dryer fabric.
56. The method of claim 55 wherein the treatment agent comprises an oil.
- 25 57. The method of claim 55 wherein a second treatment agent is applied to the drum.
58. The method of claim 57 wherein the second treatment agent comprises an oil or a synthetic resin powder.

59. The method of claim 55 wherein the treatment agent is applied to the drum.
60. The method of claim 59 wherein the second treatment agent comprises an oil or a synthetic resin powder.
- 5 61. The method of claim 28 wherein the functional additive comprises at least one of a strength agent and a sizing agent.
62. The method of claim 61 wherein the functional additive comprises a strength  
10 agent comprising a cellulose-reactive strength agent.
63. The method of claim 66 wherein the cellulose reactive strength agent comprises at least one of a polymer having epoxide functionality and polymer having aldehyde functionality.
- 15 64. The method of claim 63 wherein the cellulose reactive strength agent comprises a polymer having epoxide functionality comprising at least one of polyamido amine epichlorohydrin resin, polyamine epichlorohydrin resin.
- 20 65. The method of claim 63 wherein the cellulose reactive strength agent comprises a polymer having aldehyde functionality comprising at least one of aldehyde starch, glyoxalated polyacrylamide, urea formaldehyde resin, and melamine formaldehyde resin
- 25 66. The method of claim 61 wherein the functional additive comprises a strength agent comprising a non-cellulose-reactive strength agent.
67. The method of claim 66 wherein the non-cellulose-reactive strength agent comprises at least one of latex, latex derivative, starch, starch derivative, gum, gum

derivative, carboxymethyl cellulose, polyvinyl alcohol, homopolymer or copolymer of vinylamine, and polyacrylamide.

68. The method of claim 66 wherein the strength agent comprises a latex and the  
5 latex comprises about 0.2wt.% to 30wt.% based on dry weight of the cellulosic sheet.

69. The method of claim 66 wherein the strength agent comprises a starch, starch  
derivative, gum, or gum derivative and the starch, starch derivative, gum, or gum  
derivative comprises about 0.2wt.% to 1.5wt.% based on dry weight of the cellulosic  
10 sheet.

70. The method of claim 61 wherein the functional additive comprises a sizing agent  
comprising a cellulose reactive sizing agent.

15 71. The method of claim 70 wherein the cellulose reactive sizing agent comprises at  
least one of a ketene dimer, a ketene multimer, and an alkenyl succinic anhydride.

72. The method of claim 71 wherein the ketene dimer comprises at least one of an  
alkyl ketene dimer, an alkenyl ketene dimer, and an aryl ketene dimer.

20 73. The method of claim 28 wherein the dryer comprises at least one of a drying  
fabric and a drying drum.

74. The method of claim 73 wherein the dryer comprises a drying fabric and the  
25 treatment agent is applied to the drying fabric

75. The method of claim 73 wherein the dryer comprises a drying drum and the  
treatment agent is applied to the drying drum.

76. The method of claim 75 wherein the dryer comprises a drying fabric, and a second treatment agent is applied to the drying fabric.

5 77. In a paper machine comprising a wet end and a dryer section, wherein a wet cellulosic sheet comprising a functional additive is formed in the wet end, the dryer section comprising at least one dryer drum operated at a drying temperature, and the paper machine is operated at a machine speed, the improvement comprising applying a treatment agent to the dryer.

10 78. The method of claim 77 wherein the functional additive comprises at least one of a strength agent and a sizing agent.

79. The method of claim 77 wherein the functional additive comprises at least one cellulose reactive agent.

15

80. In a paper machine comprising a wet end and a dryer section, wherein a treatment agent is applied to the dryer, the dryer section comprising at least one dryer drum operated at a drying temperature, and the paper machine is operated at a machine speed, the improvement comprising forming a wet cellulosic sheet comprising a  
20 functional additive in the wet end.

81. In a paper machine comprising a wet end and a dryer section, wherein the paper machine is operated at a machine speed, and the dryer section comprises at least one dryer drum operated at a drying temperature, the improvement comprising:

25

- a) applying a treatment agent to the dryer; and
- b) increasing at least one of the drying temperature and the machine speed.

82. The paper machine of claim 81 wherein machine speed is increased at least about 1%.

83. The paper machine of claim 82 wherein machine speed is increased at least about 2%.
- 5 84. The paper machine of claim 83 wherein machine speed is increased at least about 4%.
85. The paper machine of claim 84 wherein machine speed is increased up to about 10%.
- 10 86. The paper machine of claim 81 wherein the drying temperature is increased at least about 2% based on degrees Kelvin.
87. The paper machine of claim 86 wherein the drying temperature is increased up to about 5% based on degrees Kelvin.
- 15

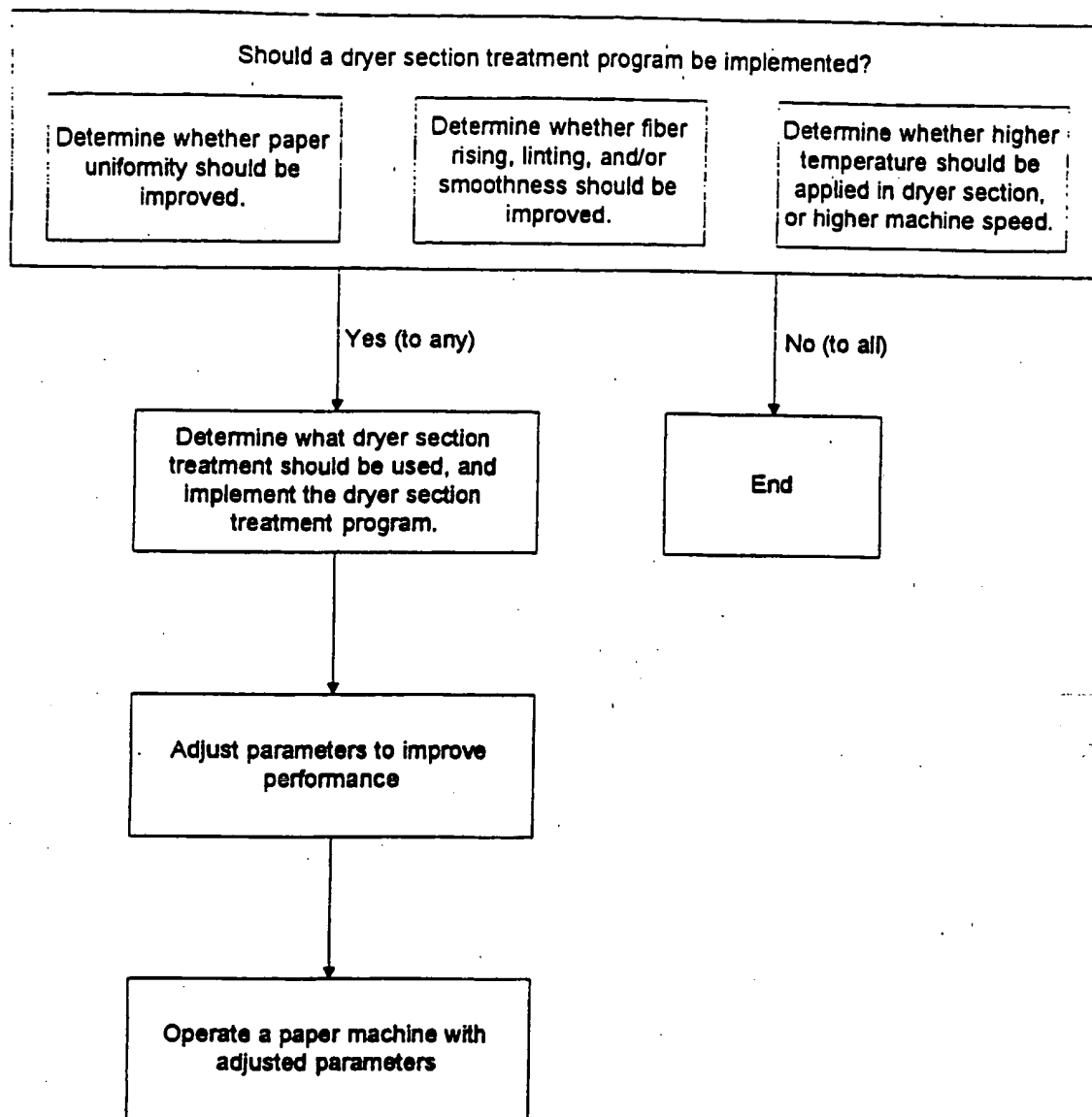


Figure 1

# INTERNATIONAL SEARCH REPORT

Intern. Application No.  
PCT/US 00/26578

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC 7 D21G9/00 D21F5/02		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) IPC 7 D21G D21F D21H		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, WPI Data, PAJ		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 824 191 A (KINSLEY JR HOMAN B) 20 October 1998 (1998-10-20)	11,12, 17,18, 24,26, 28,29, 34,61, 66,67, 73,75, 77,78,80
Y		13-16, 25,27, 30,31, 33, 35-37, 42,44, 62-65, 74,76,79
A		1,19,21, 43,45, 54,70,81
-/--		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. <input checked="" type="checkbox"/> Patent family members are listed in annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
Date of the actual completion of the international search 1 February 2001		Date of mailing of the international search report 12/02/2001
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016		Authorized officer Helpfö, T.

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 00/26578

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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